OFFICE OF NAVAL RESEARCH

QUARTERLY REPORT

for

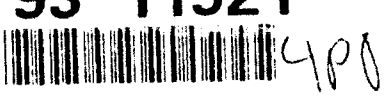
1 January 1993 through 31 March 1993

GRANT No. : N00014-89-J-1754

THE EFFECTS OF MAGNETIC STORM PHASES ON F-LAYER IRREGULARITIES FROM AURORAL TO EQUATORIAL LATITUDES

Jules Aarons and Michael Mendillo, Co-Principal Investigators

Boston University
Center for Space Physics
Boston, MA 02215



ATTENDANCE AND CONTRIBUTIONS TO THE ONR SPACE SCIENCE WORKSHOP

Both J. Aarons and M. Mendillo attended and made presentations at the ONR Space Science Workshop held in the NAS center at Irvine, CA.

Due to the need for a scientist to specialize, it is not too frequent that a scientist has the opportunity to hear what those distant in specialization are doing. This was a unique opportunity to learn the many facets of programs being supported in part or whole by ONR. Of particular interest from my point of view (J. Aarons) was the solar area. Frequently solar studies are justified and related to radio propagation on the basis of the effects of solar flares, magnetic storms, and coronal holes. I believe that both Mendillo and I contributed to the solar scientists understanding of the uses of their studies in showing the importance of solar flux on magnetically quiet periods. Certainly the phase of the sunspot cycle plays a dominating role in determining the effects of the ionosphere on equatorial propagation, a role more important than the effects of magnetic storms. Even at high latitudes, correlations with solar flux are vital for polar and auroral radio propagation. At polar latitudes, the phase of the sunspot cycle plays a dominating role in determining ionospheric radio propagation in that region. All of these roles are of importance during periods of magnetic quiet.

We were pleased to fully participate in urging areas of potential research initiatives. We proposed a campaign in our outline of possible programs.

COMPARISON OF F-LAYER IRREGULARITIES DURING PERIODS OF HIGH AND LOW SOLAR FLUX

EQUATORIAL STUDIES

Equatorial records for a limited number of months of trans-ionospheric propagation from satellite beacons transmitting at VHF frequencies were reduced and analyzed for a chain of stations in the Pacific. The study is comparing TEC and scintillation data for Manila, the Philippines, Palehua, Hawaii, Lunping, Taiwan, and Osan, Korea. Several of these observatories are spaced along a narrow range of longitudes. For some periods in 1980 and 1981, all the data are available. The data set for July 1980 and 1981 have been reduced and are being studied. The results are to be presented initially at the Naval Postgraduate School Conference on Trans-Equatorial and Near-Equatorial Radio Propagation. The abstract sent to that meeting is as follows:

DAY TO DAY VARIATIONS OF EQUATORIAL IRREGULARITIES
Jules Aarons

Abstract

F-layer irregularities in the equatorial region play a positive role in enhancing the distance possible with HF and VHF transmissions (while producing fading for communications at these frequencies). The irregularities play a disturbing role in producing fading on satellite to ground transmissions and on HF signals. Although the general pattern of equatorial F-layer irregularities as a function of latitude, longitude, and geophysical conditions is in hand, the day to day variations are still difficult to evaluate. The forcing functions for both occurrence patterns and day to day variations appear to be neutral winds and magnetic conditions. The data indicate that at times in "the irregularity season", irregularities are produced day after day. There are also periods when several nights of irregularities are followed by the absence of irreg-

ularities. The inhibition of the generation of irregularities can be in part explained as a function of magnetic conditions which do not create the necessary and sufficient conditions for the instabilities to develop. The very individuality of magnetic storms, their developmental history and their lifetime make even the identification of magnetic conditions difficult to evaluate as to whether they will or will not inhibit the generation of irregularities.

In a study of the day to day variations, we have correlated the occurrence of irregularities in the Pacific sector using the data from a relatively narrow sector of longitudes (Manila, Taiwan, Osan). The aim is to determine why the correlation is poor as far as day to day occurrence of scintillations is concerned; these data will be discussed in evaluating the possibility of forecasting irregularities.

OPTICAL DEPLETION OBSERVATIONS OF ELECTRON DENSITY IN THE EQUATORIAL REGION

We have completed initial studies of airglow depletion data taken in Brazil over a long time period which include years of both high and low solar flux. The equipment and operation were funded by other agencies but ONR funds were used in the analysis of the data. The initial analysis is completed; the abstract of the paper sent to the Journal of Atmospheric and Terrestrial Physics is as follows:

OI 630. nm IMAGING OBSERVATIONS OF EQUATORIAL PLASMA DEPLETIONS AT 16° S DIP LATITUDE

Y. Sahai, J. Aarons*, M. Mendillo*, J. Baumgardner*
J.A. Bittencourt and H. Takahashi

Instituto Nacional de Pesquisas Espaciais - INPE
C. P. 515, 12201 Sao Jose dos Campos, SP, Brasil

*Center for Space Physics, Boston University
Boston, MA 02215, USA

ABSTRACT

Equatorial ionospheric irregularities in the F layer have been the subject of intensive experimental and theoretical investigations during recent years. The class of irregularities which continues to receive much attention is characterized by large scale plasma depletions, generally referred to as ionospheric plumes and bubbles. The F-region nightglow emissions arising from recombination processes can be used to observe the dynamics of transequatorial ionospheric plasma bubbles and smaller scale plasma irregularities. In a collaborative project between the Center for Space Physics of Boston University and the Brazilian Institute for Space Research (INPE), an all-sky imaging system was operated at Cachoeira Paulista (22.7° S, 45.0° W, dip latitude 15.8° S), between March 1987 and October 1991. In addition to the imager, photometer and VHF polarimeter observations were conducted at Cachoeira Paulista with ionospheric soundings carried out at C. Paulista and Fortaleza, the latter at 3.9° S. 38.4° W, dip latitude 3.7° S. A VHF electronic polarimeter is in operation at C. Paulista. This long series of OI 630.0 nm imaging observations has permitted us to determine that when there are extended plumes, the altitudes affected over the magnetic equator often exceed 1500 km and probably exceed 2500 km at times, the maximum projection that can be seen from Cachoeira Paulista. This holds true even during years of low solar flux. For this longitude, the observed seasonal variation of the airglow depletions shows a maximum from October through March and a very low occurrence of airglow depletions from April through September.

HIGH LATITUDE STUDIES

We have analyzed the data provided by Dr. Leonard Kersley of the University College of Aberystwyth, Wales and his group. Data from several periods of interest in the low sunspot years of 1985 and 1986 has been contoured. The data available for the study of contrasting low and high solar flux years includes that from the University College data set taken in Kiruna, Sweden as well as other data taken in Goose Bay, Labrador. We also have access to equatorial observations for these dates. Evaluation of data sets has included new analysis as well as the utilization of older data, much of which has been merely reduced but not used in research studies.

PROPOSED PREPRINT AND PRESENTATION PAPERS FOR IES

We have completed the preprint version of the paper "The sunspot cycle and "auroral" F layer irregularities". The authors are J. Aarons, L. Kersley (University of Wales) and A.S. Rodger (British Antarctic Survey); a request for clearance has been initiated (and as of the middle of April has been granted).

A second paper has been completed for preprint status for the Ionospheric Effects Symposium. The study was being made with Charles Rush of National Telecommunications and Information Administration. A national interest in this area is apparent since the low orbit satellite program has been allocated use of frequencies near 136 MHz. The system is to be used for position determination, paging, and many other applications. The title of the paper by Aarons and Rush is "The effects of scintillation on 136-150 MHz earth-space propagation paths" A request for clearance has been initiated (and granted as of the middle of April).